Smart Waste Management System for Metropolitan Cities

PROJECT REPORT

Submitted by

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1. INTRODUCTION

1.1 Project Overview

Increasing waste generation has become a significant challenge in developing countries due to unprecedented population growth and urbanization and improper collection and disposal mechanism used for waste material, the increase in moving trends of peoples toward big cities and lack of intelligent technology used to support the municipal solid waste management system. Consequently, the management of waste material has become a challenge due to a large amount of waste littered everywhere. Furthermore, various problems also occur due to the existing systems that are not only inadequate and inefficient but also their non-scientific procedures involved in the solid waste management. In this paper, an IoT-based Smart Waste Management System for Metropolitan Cities is proposed.

1.2 Purpose

For the management of waste in smart cities, there are many factors that play a significant role to make the waste management more challenging, for an example, rapid growth of population, shifting of population from small cities to big cities, geographical location, system administration, improper way of collection and disposal of waste, This system helps to solve the problems associated with management of waste material in the Metropolitan Cities using the IoT-based waste collection for the smart city as discussed above.

2. LITERATURE SURVEY

2.1 Existing problem

The waste generation in big cities is increasing rapidly from the last two decades. As per the studies conducted it is expected that the annual solid waste generation will reach around 3.40 billion tones that would lead to an approximately cost of $635.5 billion in the management of municipal waste management many issues have been investigated that signify direct connection with the increase in waste material generation and related difficulties to handle it in a smart city.

2.2 References.

T. Sinha,R.M Sahuother : IOT Based smart garbage system

IoT Based Smart Garbage System which indicates directly that the dustbin is filled to a certain level by the garbage and cleaning or emptying them is a matter of immediate concern. This prevents slumping of garbage in the roadside dustbin which ends up giving foul smell and illness to people. The design of the smart dustbin includes a single by ultrasonic sensor which configured with Arduino Uno with this research, it is sending SMS to the Municipal Council that particular dustbin is to overflow.

Shaik Vaseem Akram, Rajesh Singh: Raspberry pi-based smart waste management system using Internet of Things.

Nowadays it is becoming a difficult task to distinguish wet and dry waste. The new waste management system covers several levels of enormous workforce. Every time laborers must visit the garbage bins in the city area to check whether they are filled or not. The data communicates to the cloud server for real-time monitoring of the system. With the real-time fill level information collected via the monitoring platform, the system reduces garbage overflow by informing about such instances before they arrive.

Mohd Helmy AbdWahab: Smart Solid Waste Management. At the time of trash disposal, the material to be recycled could be identified using RFID technology.

Ranjeet Kumar, Sandeep Chhabra: Analysis of Load cell. Load Cells 4.1 General Load Cell related information A load cell is meant to measure the size of a mass but actually is a force sensor which transforms force into an electrical signal. The load cell needs the earth gravity to work. Every mass is attracted by the earth gravimetric field, that force is named "load". recovered, to provide end users with traffic analysis and provide useful predictions.

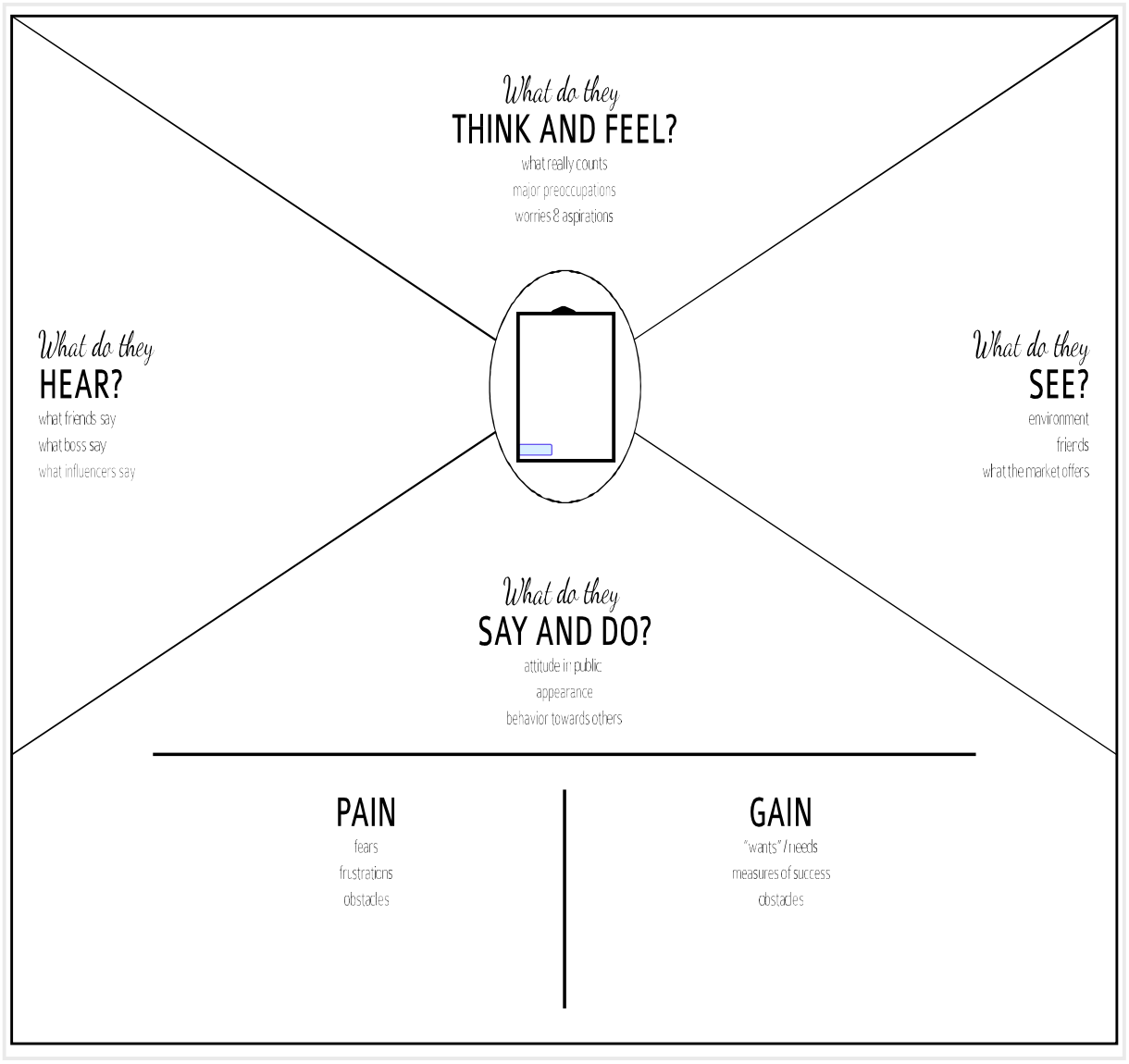
Nikhita Reddy Gade, et.al. (2016): Today the world is connected. The number of devices that are connected are increasing day by day. Many studies show that about 50 billion devices will be connected in 2020 indicating that Internet of things has a very important role to play in the future to come paper. One such solution is the development of a smart world. In recent years, the concept of smart city has played an important role in academic and industry fields, with the progress and functioning of various platforms and infrastructures based on IO.

2.3 Problem Statement Definition

This project deals with the problem of waste management in smart cities, where the garbage collection system is not optimized. This project enables the organizations to meet their needs of smart garbage management systems. This system allows the authorized person to know the fill level of each garbage bin in a locality or city at all times, to give a cost-effective and time-saving route to the truck drivers.

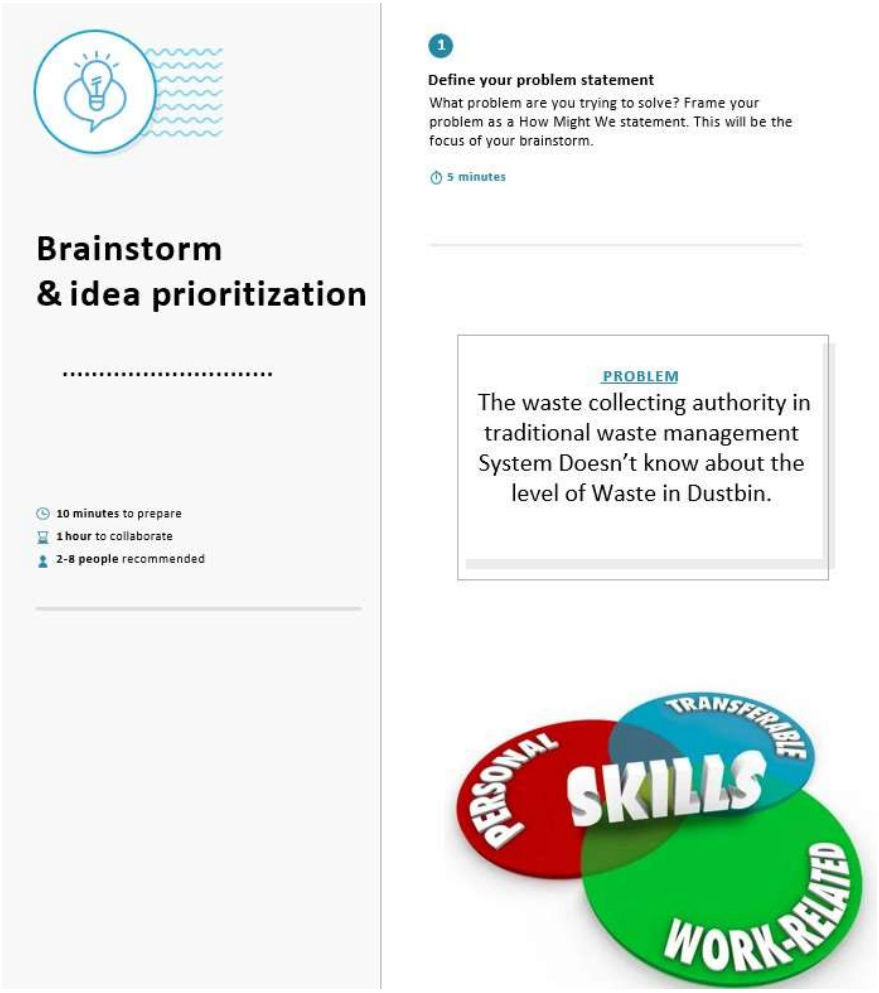
3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

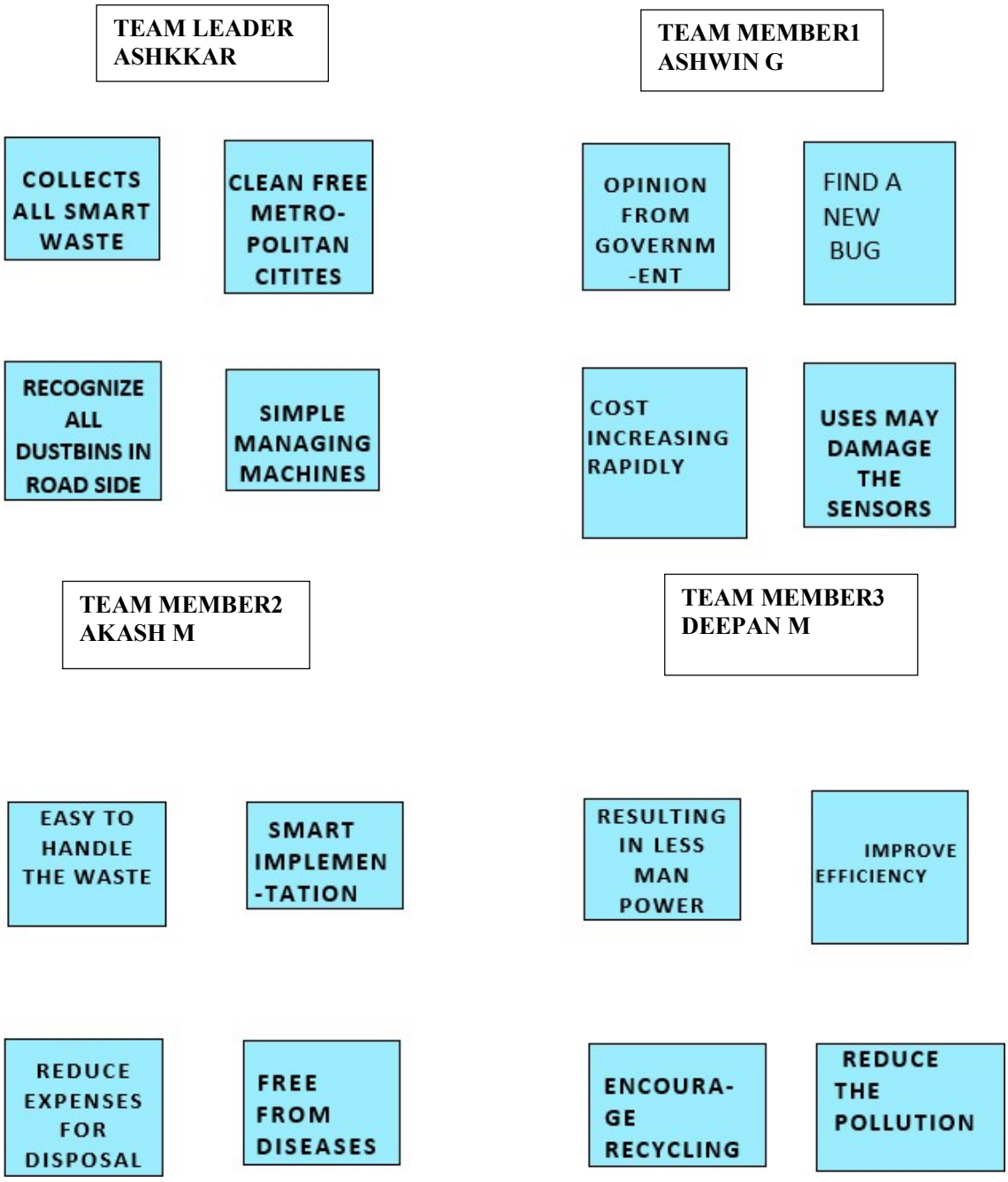


3.2 Ideation & Brainstorming

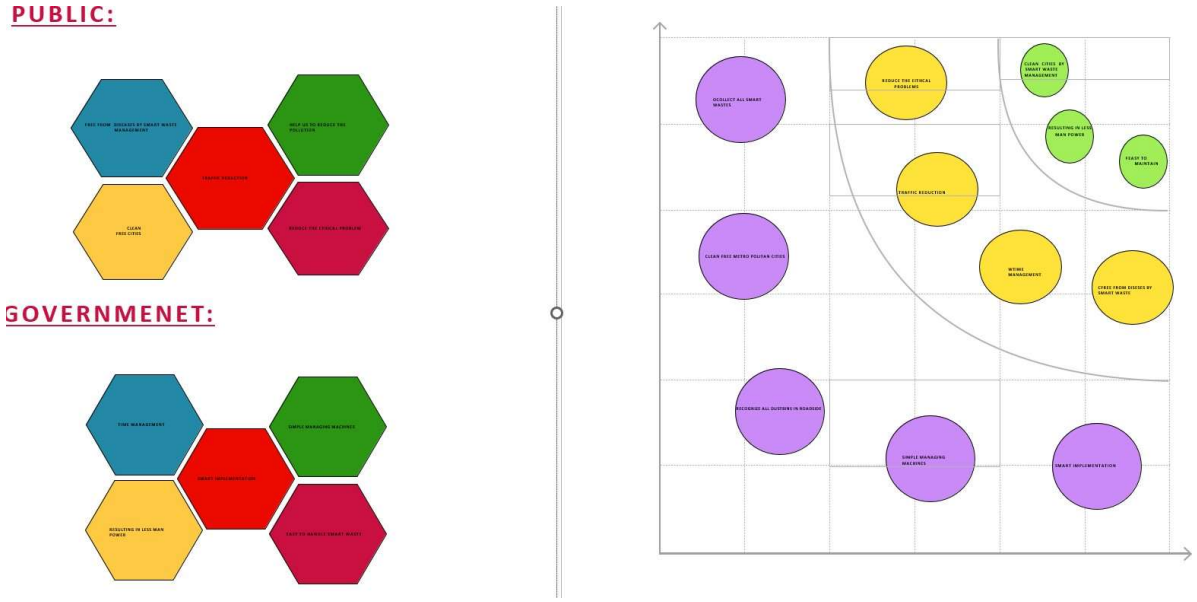
Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing & Grouping



Step-3: Idea Prioritization



3.3 Proposed Solution

The proposed system would be able to automate the solid waste monitoring process and management of the overall collection process using IOT (Internet of Things).

• The Proposed system consists of main subsystems namely Smart Trash System (STS) and Smart Monitoring and Controlling Hut (SMCH).

• In the proposed system, whenever the wastebin gets filled this is acknowledged by placing

• the circuit at the waste bin, which transmits it to the receiver at the desired place in the area or spot.

• In the proposed system, the received signal indicates the waste bin status at the monitoring
and controlling system.

3.4 Problem Solution fit

We are going to establish SWM in our college but the real hard thing is that janitor (cleaner) doesn't know to operate these things practically so here our team planned to build a wrist band to them, that indicate via light blinking when the dustbin fills and this is Uniqueness, we made here beside from project constrain.

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

System Required:

RAM-Minimum 4GB Processor-Min. Configuration OS-Windows/Linux/MAC

- Garbage level detection in bins.
- Getting the weight of the garbage in the bin.
- Alerts the authorized person to empty the bin whenever the bins are full.
- Garbage level of the bins can be monitored through a web App.
- We can view the location of every bin in the web application by sending GPS location from the device.

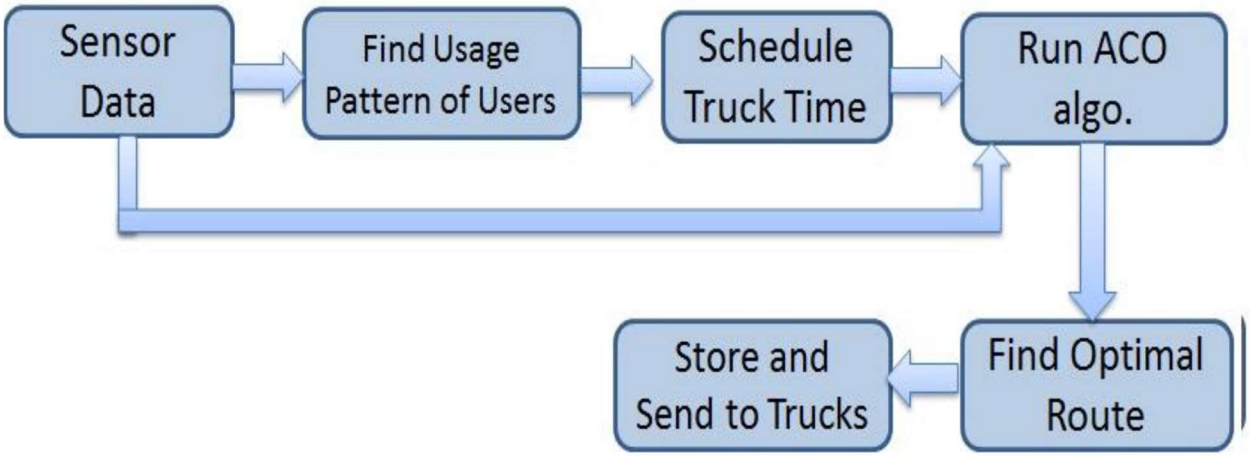
4.2 Non-Functional requirements

Software Required:

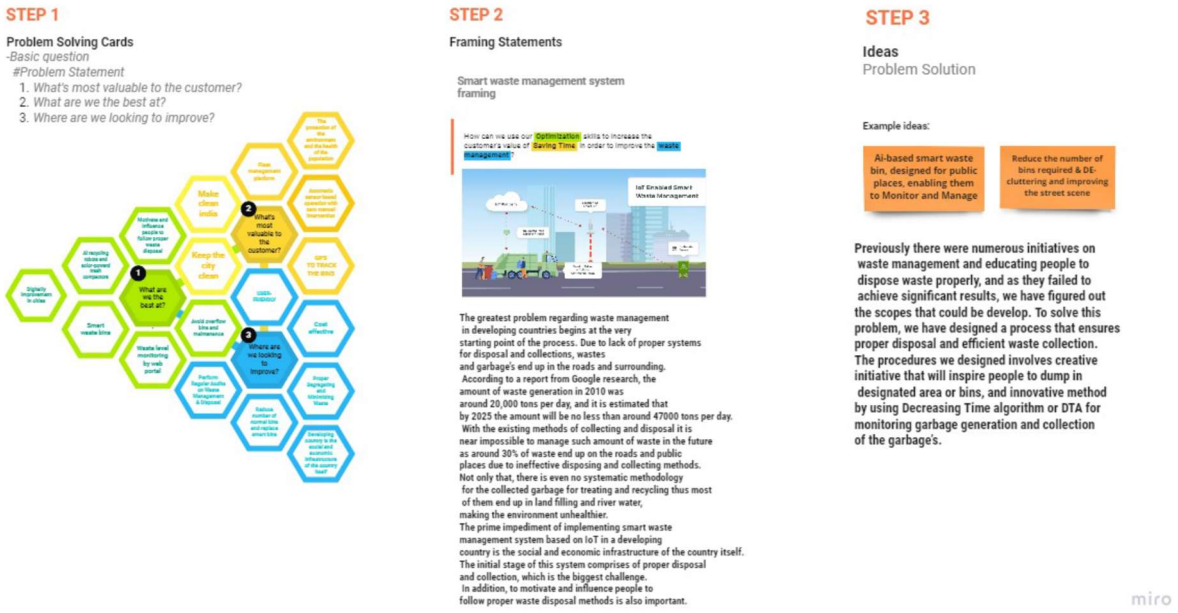
Python IDLE

5. PROJECT DESIGN

5.1 Data Flow Diagrams



5.2 Solution & Technical Architecture



5.3 User Stories

In this regard, smart city design has been increasingly studied and discussed around the world to solve this problem. Following this approach, this paper presented an efficient IoT-based and real-time waste management model for improving the living environment in cities, focused on a citizen perspective. The proposed system uses sensor and communication technologies where waste data is collected from the smart bin, in real-time, and then transmitted to an online platform where citizens can access and check the availability of the compartments scattered around a city

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Objective	USN-1	The smart bin system will alert the nearby garbage collectors when the bin overflows.	6	High	ASHK KAR SIDHI K B S
Sprint-1	Registration	USN-2	The user(garbage collectors) can register for the application using the respective credentials provided to them.	4	Medium	ASHK KAR SIDHI K B S
Sprint-1	Designing	USN-3	Designing a circuit with sensors and arduino interface	6	High	ASHK KAR SIDHI K B S
Sprint-1	Cloud	USN-4	As an administrator, register in IBM cloud	4	Medium	ASHK KAR SIDHI K B S
Sprint-2	Code development	USN-5	Develop a code to send a message when the bin overflows using ultrasonic sensor	10	High	DEEPA N M

6.2 Sprint Delivery Schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-2	Cloud Server	USN-6	Cloud web server is created which connects the bin and the authority who is responsible for the disposal of waste from its bin	10	High	DEEPAN M
Sprint-3	Sensor	USN-7	Detect the level of garbage using sensor and store it in the server for specific interval of time.	10	High	ASHWIN G
Sprint-3	Cloud	USN-8	Authority should allocate which garbage collector should collect the waste at particular area	10	High	ASHWIN G
Sprint-4	Communicating Medium	USN - 9	Garbage collector receives the message from the authority and goes to collect the garbage	10	High	AKASH M

Sprint-4	Communicating Medium	USN-10	Once the garbage is collected the particular person should intimate the completion of the task	5	Medium	AKASH M
Sprint -4	Cloud database	USN-11	Update the database after task completion	5	Medium	AKASH M

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1

Functional Requirement–Signin/Signup **User story : USN−1**

HTML CODE :

```
<!DOCTYPE html>
<html lang="en">
 <head>
  <meta charset="UTF-8" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
  <title>Smart Waste Management System</title>
  <!-- Bootstrap 4 CSS CDN -->
  <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/twitter-bootstrap/4.5.2/css/bootstrap.min.css" />
<!-- Fontawesome CSS CDN -->
  <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/font-awesome/5.14.0/css/all.min.css" />
  <link rel="stylesheet" href="css/style.css" />
 </head>
 <body class="bg-info">
```

```
<div class="container">
<!-- Login Form Start -->
<div class="row justify-content-center wrapper" id="login-box">
<div class="col-lg-10 my-auto myShadow">
<div class="row">
<div class="col-lg-7 bg-white p-4">
<h1 class="text-center font-weight-bold text-primary">Sign in</h1>
<hr class="my-3" />
<form action="#" method="post" class="px-3" id="login-form">
<div class="input-group input-group-lg form-group">
<div class="input-group-prepend">
<span class="input-group-text rounded-0"><i class="far fa-envelope fa-lg fa-fw"></i></span>
</div>
<input type="email" id="email" name="email" class="form-control rounded-0" placeholder="E-Mail" required />
</div>
<div class="input-group input-group-lg form-group">
<div class="input-group-prepend">
<span class="input-group-text rounded-0"><i class="fas fa-key fa-lg fa-fw"></i></span>
```

```
        </div>
        <input type="password" id="password" name="password"
class="form-control rounded-0" minlength="5" placeholder="Password"
required autocomplete="off" />
      </div>
      <div class="form-group clearfix">
       <div class="custom-control custom-checkbox float-left">
        <input type="checkbox" class="custom-control-input"
        id="customCheck" name="rem" />
        <label class="custom-control-label"
        for="customCheck">Remember me</label>
       </div>
       <div class="forgot float-right">
        <a href="#" id="forgot-link">Forgot Password?</a>
       </div>
      </div>
      <div class="form-group">
       <input type="submit" id="login-btn" value="Sign In"
       class="btn btn-primary btn-lg btn-block myBtn" />
      </div>
     </form>
    </div>
    <div class="col-lg-5 d-flex flex-column justify-content-center
    myColor p-4">
     <h1 class="text-center font-weight-bold text-white">Welcome
     Friend!</h1>
     <hr class="my-3 bg-light myHr" />
     <p class="text-center font-weight-bolder text-light lead">Start
     your initiative to make your environment clean</p>
     <button class="btn btn-outline-light btn-lg align-self-center font-
```

```
weight-bolder mt-4 myLinkBtn" id="register-link">Sign
Up</button>
</div>
</div>
</div>
</div>
<!-- Login Form End -->
<!-- Registration Form Start -->
<div class="row justify-content-center wrapper" id="register-box"
style="display: none;">
<div class="col-lg-10 my-auto myShadow">
<div class="row">
<div class="col-lg-5 d-flex flex-column justify-content-center myColor p-
4">
<h1 class="text-center font-weight-bold text-white">Welcome
Back!</h1>
<hr class="my-4 bg-light myHr" />
<p class="text-center font-weight-bolder text-light lead">To stay
connected Please login with your personal info.</p>
<button class="btn btn-outline-light btn-lg font-weight-bolder mt-
4 align-self-center myLinkBtn" id="login-link">Sign In</button>
</div>
<div class="col-lg-7 bg-white p-4">
<h1 class="text-center font-weight-bold text-primary">Create
Account</h1>
<hr class="my-3" />
```

```
<form action="#" method="post" class="px-3" id="register-form">
 <div class="input-group input-group-lg form-group">
  <div class="input-group-prepend">
   <span class="input-group-text rounded-0"><i class="far fa-user fa-lg fa-fw"></i></span>
  </div>
  <input type="text" id="name" name="name" class="form-control rounded-0" placeholder="Full Name" required />
 </div>
 <div class="input-group input-group-lg form-group">
  <div class="input-group-prepend">
   <span class="input-group-text rounded-0"><i class="far fa-envelope fa-lg fa-fw"></i></span>
  </div>
  <input type="email" id="remail" name="email" class="form-control rounded-0" placeholder="E-Mail" required />
 </div>
 <div class="input-group input-group-lg form-group">
  <div class="input-group-prepend">
   <span class="input-group-text rounded-0"><i class="fas fa-key fa-lg fa-fw"></i></span>
  </div>
  <input type="password" id="rpassword" name="password" class="form-control rounded-0" minlength="5" placeholder="Password" required />
 </div>
 <div class="input-group input-group-lg form-group">
  <div class="input-group-prepend">
   <span class="input-group-text rounded-0"><i class="fas fa-key
```

```
 fa-lg fa-fw"></i></span>
</div>
<input type="password" id="cpassword" name="cpassword"
class="form-control rounded-0" minlength="5" placeholder="Confirm
Password" required />
</div>
<div class="form-group">
<div id="passError" class="text-danger font-weight-
bolder"></div>
</div>
<div class="form-group">
<input type="submit" id="register-btn" value="Sign Up"
class="btn btn-primary btn-lg btn-block myBtn" />
</div>
</form>
</div>
</div>
</div>
</div>
<!-- Registration Form End -->
<!-- Forgot Password Form Start -->
<div class="row justify-content-center wrapper" id="forgot-box"
style="display: none;">
```

```
<div class="col-lg-10 my-auto myShadow">
 <div class="row">
  <div class="col-lg-7 bg-white p-4">
   <h1 class="text-center font-weight-bold text-primary">Forgot Your Password?</h1>
   <hr class="my-3" />
   <p class="lead text-center text-secondary">To reset your password, enter the registered e-mail adddress and we will send you password reset instructions on your e-mail!</p>
   <form action="#" method="post" class="px-3" id="forgot-form">
    <div id="forgotAlert"></div>
    <div class="input-group input-group-lg form-group">
     <div class="input-group-prepend">
      <span class="input-group-text rounded-0"><i class="far fa-envelope fa-lg"></i></span>
     </div>
     <input type="email" id="femail" name="email" class="form-control rounded-0" placeholder="E-Mail" required />
    </div>
    <div class="form-group">
     <input type="submit" id="forgot-btn" value="Reset Password" class="btn btn-primary btn-lg btn-block myBtn" />
    </div>
   </form>
  </div>
  <div class="col-lg-5 d-flex flex-column justify-content-center myColor p-4">
   <h1 class="text-center font-weight-bold text-white">Reset Password!</h1>
```

```
        <hr class="my-4 bg-light myHr" />
        <button class="btn btn-outline-light btn-lg font-weight-bolder
        myLinkBtn align-self-center" id="back link">Back</button>
       </div>
      </div>
     </div>
    </div>
<!-- Forgot Password Form End -->
   </div>
   <!-- jQuery CDN -->
   <script
   src="https://cdnjs.cloudflare.com/ajax/libs/jquery/3.5.1/jquery.min.js
   "></script>
   <script src="js/script.js"></script>
  </body>
 </html>
```

CSS CODE :

```
@import
url("https://fonts.googleapis.com/css?family=Maven+Pro:400,500,600,
700,800,900&display=swap");


* {
 margin: 0;
padding: 0; box-
sizing: border-
box; font-
family: "Maven
Pro", sans-serif;
}
.wrapper
{ height: 100vh;}
.myColor
{
 background-image: linear-gradient(to right, #324bf3 50%, #f9d423
 150%);
}
.myShadow {
 box-shadow: 0 10px 10px rgba(0, 0, 0, 0.5);
}
.myBtn { border-radius: 50px;
font-weight: bold; font-size:
20px; background-image: linear-
```

```
gradient(to right, #0acffe 0%,
#495aff 100%); border: none;
}
.myBtn:hover { background-image:
linear-gradient(to right, #495aff
0%, #0acffe 100%);
}
.myHr {
height:
2px;
border-
radius:
100px;
}
.myLinkBt
n { border-
radius:
100px;
width:
50%;
border:
2px solid
#fff;
```

```
}
@media (max-width: 720px) {
 .wrappe
  r {
  margin:
  2px;
 }
}
```

JS CODE:

```
$(function () {
 $("#register-link").click(function () {
  $("#login-box").hide();
  $("#register-box").show();
 });
 $("#login-link").click(function () {
  $("#login-box").show();
  $("#register-box").hide();
 });
 $("#forgot-link").click(function () {
  $("#login-box").hide();
  $("#forgot-box").show();
 });
 $("#back-link").click(function () {
  $("#login-box").show();
  $("#forgot-box").hide();
```

```
});

});
```

7.2 Feature 2

Code for Data Transfer from Sensors

```
#include <WiFi.h>                  // library for wifi
#include <PubSubClient.h>          // library
for MQTT #include
<LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 20, 4);

//_____credentials of IBM Accounts .....

#define ORG "9gbe4w"               // IBM organisation id
#define DEVICE_TYPE "SWMSMC"       // Device type mentioned in ibm
watson iot platform
#define DEVICE_ID "ibmproject"             // Device ID
mentioned in ibm watson iot platform #define TOKEN
"sUNA41tG6-Pq)0rk5X"     // Token

//.....customise above values  .....

char server[]  = ORG
".messaging.internetofthings.ibmcloud.com";
                                           // server
name char publishTopic[] = "iot-
2/evt/data/fmt/json";
char topic[] = "iot-2/cmd/led/fmt/String";        // cmd Represent type and
command is test format of strings
char authMethod[] = "use-token-auth";     // authentication
```

```
method char token[] = TOKEN; char clientId[] = "d:" ORG
":" DEVICE_TYPE ":" DEVICE_ID; //Client id

//_____

WiFiClient wifiClient;                    // creating
instance for wificlient PubSubClient client(server,
1883, wifiClient);

#define
ECHO_PIN 12
#define
TRIG_PIN 13
float dist;

void setup()
{
 Serial.begin(115
200);
pinMode(LED_BU
ILTIN, OUTPUT);
pinMode(TRIG_P
IN,
                OUT
PUT);
pinMode(ECHO
_PIN, INPUT);
 //pir pin
 pinMode(
 4,
 INPUT);

 //ledpins
pinMode(23
,
OUTPUT);
pinMode(2,
```

```
OUTPUT);
pinMode(4,
OUTPUT);
 pinMode(15, OUTPUT);


 lcd.init();
lcd.backli
ght();
lcd.setCurs
or(1, 0);
```

```
lcd.print(""
);
wifiConnect(
);
mqttConnec
t();
  }

  float readcmCM()
  {
   digitalWrite(TRI
  G_PIN, LOW);
  delayMicrosecon
  ds(2);
  digitalWrite(TRI
  G_PIN, HIGH);
  delayMicrosecon
  ds(10);
  digitalWrite(TRI
  G_PIN, LOW);
  int duration =
  pulseIn(ECHO_PI
  N, HIGH); return
  duration * 0.034 /
  2;
  }

  void loop()
  {

   lcd.clear();

   publishDat
  a();
  delay(500)
  ;
   if (!client.loop())
```

```
  {
   mqttConnect();                          // function call to connect to IBM
 }
 }
 /*.....retrieving to cloud.....*/
 void wifiConnect()
 {
  Serial.print("C
  onnecting to ");
  Serial.print("W
  ifi");
  WiFi.begin("Wok
  wi-GUEST", "",
  6);
  while (WiFi.status() != WL_CONNECTED)
   {
delay(50
       0);
Serial.print(".");
   }
  Serial.print("WiFi connected, IP address: ");
  Serial.println(WiFi.localIP());
 }
 void mqttConnect()
  {
   if (!client.connected())
    {
     Serial.print("Reconnecti
 ng MQTT client to ");
 Serial.println(server); while
 (!client.connect(clientId,
 authMethod, token))
     {
      Serial.p
      rint(".")
```

```
    ;
    delay(5
    00);
   }
  initManagedDevice();
   Serial.println();
 }
}
void initManagedDevice()
{
 if (client.subscribe(topic))
```

```
    {
    Serial.println("IBM subscribe to cmd OK");
    }
else
  {
  Seri
  al.p
  rint
  ln("
  s
  ubs
  crib
  e to
  cm
  d
  FAI
  LE
  D"
  );
    }
  }
  void publishData()
  {
   float cm = readcmCM();

   if(digitalRead(34))                    //PIR motion detection
  {
    Serial.println("Motion Detected");
  Serial.println("Li
  d
                  Ope
  ned");
  digitalWrite(15,
  HIGH);

  }
   else
```

```
 {
  digitalWrite(15, LOW);
 }

if(digitalRead(34)== true)
{
 if(cm <= 100)                          //Bin level detection
 {
  digitalWrite(2, HIGH);
  Serial.println("High Alert!!!,Trash bin is about to be full");
  Serial.println("L
id Closed");
lcd.print("Full!
Don't use");
delay(2000);
  lcd.clear(
);
digitalWrit
e(4,
LOW);
digitalWrit
e(23,
LOW);
 }
 else if(cm > 150 && cm < 250)
 {
  digitalWrite(4, HIGH);
  Serial.println("Warning!!,Trash
is about to cross 50% of bin level");
digitalWrite(2, LOW);
digitalWrite(23, LOW);
 }
 else if(cm > 250 && cm <=400)
 {
  digitalWrite(2
3,
```

```
                    HI
GH);
Serial.println("
Bin                 is
available");
digitalWrite(2,
LOW);
 digitalWrite(4, LOW);
}
 delay(10000);
 Serial.println("Lid Closed");
}
else
{
 Serial.println("No motion detected");
```

```
}


 if(cm <= 100)
{
digitalWrite(21,HIGH);
String
payload =
"{\"High
Alert!!\":\"";
payload +=
cm; payload
+= "left\" }";
Serial.print("\n");
Serial.print("Sending payload:
"); Serial.println(payload);
if (client.publish(publishTopic, (char*) payload.c_str()))       // if data is
uploaded to cloud successfully,prints publish ok or prints publish
failed
{
Serial.println("Publish OK");
}
}
if(cm <= 250)
{
digitalWrite(22,HIGH);
String
payload =
"{\"Warning!
!\":\"";
payload +=
dist; payload
+= "left\"
}";
Serial.print("\n");
```

```
Serial.print("Sending distance:
"); Serial.println(cm);
if(client.publish(publishTopic,
(char*) payload.c_str()))
{
Serial.println("Publish OK");
}
else
{
Serial.println("Publish FAILED");
}
}

 float inches = (cm / 2.54);                    //print on LCD
lcd.setCursor(0,0); lcd.print("Inches");
lcd.setCursor(4,0); lcd.setCursor(12,0);
lcd.print("cm"); lcd.setCursor(1,1);
lcd.print(inches, 1); lcd.setCursor(11,1);
lcd.print(cm, 1); lcd.setCursor(14,1);
delay(1000); lcd.clear();
}
```

8. ADVANTAGES & DISADVANTAGES

ADVANTAGES

- It saves time and money by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs by upto30%.

- It decreases traffic flow and consecutively noise due to less air pollution as result of less waste collection vehicles on the roads. This has become possible due to two-way communication between smart dustbins and service operators.
- It keeps our surroundings clean and green and free from bad odor of wastes, emphasizes on healthy environment**.**
- It further reduces manpower requirements to handle the garbage collection process.
- Applying smart waste management process to the city optimizes management, resources and costs which makes it a"smart city".It helps administration to generate extra revenue by advertisements on smart devices.

DISADVANTAGES

- System requires more number of waste bins for separate waste collection as per population in the city.
- This results into high initial cost due to expensive smart dustbins compare to other methods.
- Sensor nodes used in the dustbins have limited memory size.
- Wireless technologies used in the system such as ZigBee and wifi have shorter range and lower data speed. In RFID based systems, RFID tags are affected by surrounding metal objects (if any).
- It reduces man power requirements which results into increase in unemployment for unskilled people.

- The training has to be provided to the people involved in the smart waste management system.

9. CONCLUSION

In this paper, smart waste management using Internet of Things has been discussed. The report has given solutions to the problems such as sensing the data, analyzing the data, collecting data, processing the collected data and getting output result for effective handling of waste. The system is designed based on an IoT sensing prototype that measures the waste level of bins and sends the information to the server via internet services.

The data stored on the server as well as over the cloud is used for further processing and analysis. Based on this data, the collection area is divided into five regions and four routes are further created which were then assigned to waste-truck to hit the filled bins successfully in the simulation. The paper is mainly focused on the efficiency and operational cost of the system.

10. APPENDIX

GitHub & Project Demo Link

https://github.com/IBM-EPBL/IBM-Project-9797-1659075876